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(पहला पुनरीक्षण)

Indian Standard

OPTICAL INSTRUMENTS — BUBBLES — SPECIFICATION

(*First Revision*)

UDC 532·291 : 681·2

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BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

March 1993

Price Group 4

Optical and Mathematical Instruments Sectional Committee, LM 20

FOREWORD

This Indian Standard (First Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Optical and Mathematical Instruments Sectional Committee had been approved by the Light Mechanical Engineering Division Council.

This standard was first published in 1960. In this revision clauses **3.2** and **5.2.3** have been modified and Annex A recommending method of testing has been incorporated.

Bubbles are specifically designed for different types of instruments in which they are to be fitted and used. Their sensitivity depends on the accuracy of the instrument and its function, and the size of such a bubble is governed by the restrictions of space available for its fitting in each different type of instrument. There is a tendency to order bubbles which may be unnecessarily sensitive for the purpose in view. It should be realized that a 10-second bubble read to 0.1 division is effectively a better means of obtaining an accuracy of 1 second than a 2-second bubble read to 0.5 division. The 10-second bubble would prove more reliable in use, would retain its zero adjustment and would be less affected by draughts or local temperature changes. The purchaser shall, therefore, stipulate the size as well as the sensitivity required by him.

This specification deals in detail with the requirements, for the precision type of bubbles, but the general contents are applicable to the coarser bubbles as well. In the case of the latter, however, some of the requirements and tests may be relaxed or waived.

Taking into consideration the views of producers, consumers and testing authorities, the Sectional Committee responsible for the preparation of this standard felt that it should be related to the manufacturing and trade practices followed in the country in this field. Furthermore, due weightage had to be given to the need for international co-ordination among standards prevailing in different countries of the world in this field. These considerations led the Sectional Committee to derive assistance from the following publications:

BS 958 : 1941 'Precision levels for engineering workshops' issued by the British Standards Institution.

BS 3509-1962 'Spirit level vials' issued by the British Standards Institution.

Metric system has been adopted in India and all dimensions in this standard have been given in this system.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

This standard is intended chiefly to cover the technical provisions relating to bubbles, and it does not include all the necessary provisions of a contract.

Indian Standard

OPTICAL INSTRUMENTS — BUBBLES — SPECIFICATION

(First Revision)

1 SCOPE

1.1 This specification covers bubbles, ground, unground and moulded or fabricated, either in cylindrical or circular form intended for use in precision surveying, inspection, and general levelling purposes.

1.2 The requirement of this specification shall also apply to mounted bubbles.

1.2.1 As mountings are designed to suit special purposes in the diverse engineering practices, this specification does not cover details of those fitments.

2 TERMINOLOGY

2.0 For the purpose of this standard, the following definitions shall apply.

2.1 Bubble

The bubble is a device which when fitted to an instrument can be used to define a reference horizontal plane as in levelling. It consists of a glass tube containing a filling liquid having low viscosity and which maintains its fluidity over a fairly wide range of temperature, thereby making its use possible at low temperatures as well.

2.2 Bubble Vial

A sealed glass tube suitably processed, partially filled with a liquid of low freezing point and low viscosity leaving an 'air-bell' inside.

2.3 Air-Bell

The small space, created inside the sealed tube due to its partial filling, which forms a bubble of mixed air and liquid vapour.

2.4 Bubble Run

The travel of the 'air-bell' inside the tube corresponding to any angular tilt given to the bubble.

2.5 Sensitivity

The sensitivity of a bubble is the angle of tilt which would cause its 'air-bell' to move through one scale division.

2.6 Roll

The rotation of the bubble round an axis which is parallel to the axis of the bubble.

2.7 Effective Range

The internally processed surface of the bubble which responds correctly to the various functional requirements and is usually confined to the limits of the etched lines.

2.8 Consistency

The characteristic of the 'air-bell' of the bubble each time to set itself to its original position throughout its effective range when such a setting is disturbed and restored.

2.9 Sluggishness

The incapability of the 'air-bell' to exhibit corresponding deviations in its position as warranted by small changes in tilt.

2.10 Mounts

The cases in which the bubbles are housed or mounted for particular uses.

2.11 Roll Error

The longitudinal movement of the bubble (due to imperfections in the ground surface of the vial) when rolled through a specified angle about its axis.

2.12 Settling Time

The time taken for a bubble to return to its steady position when the vial has been tilted through a specified angle.

3 TYPES, SIZES AND SENSITIVITIES

3.1 Types

The bubbles shall be of the following two types:

a) Cylindrical, and

b) Circular.

3.2 Sizes

The preferred overall lengths and diameters for cylindrical bubbles, and the preferred diameters and overall heights for circular bubbles shall be as given in Table 1 read with Fig. 1A and 1B. The pip should be as small as possible.

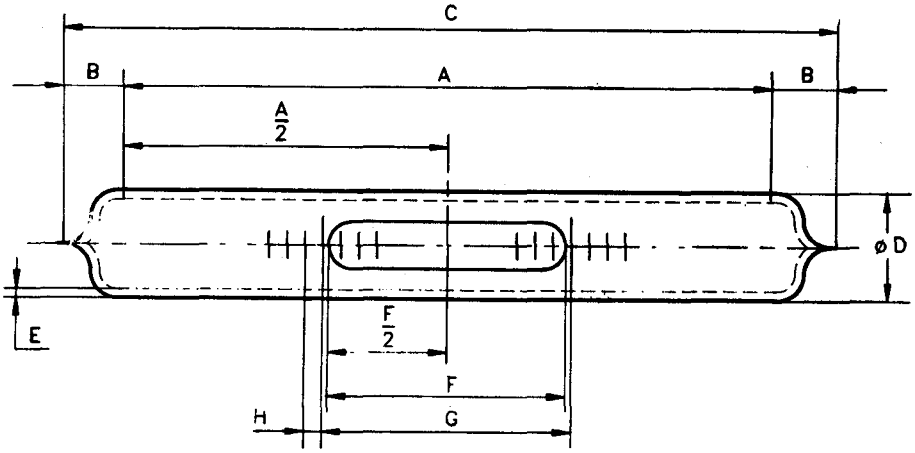


FIG. 1A DIMENSIONAL NOMENCLATURE FOR STRAIGHT VIAL

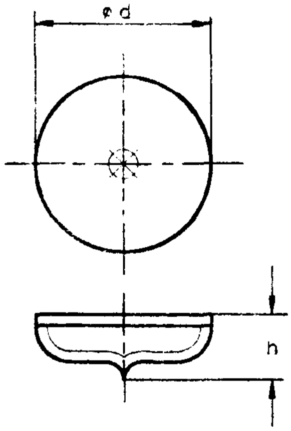


FIG. 1B DIMENSIONAL NOMENCLATURE FOR CIRCULAR VIAL

Table 1 Dimensions for Bubbles

(*Clause* 3.2)

All dimensions in millimetres.

Dimension	**Dimensions for Cylindrical Bubbles**											
A (*Min*)	200	180	130	100	90	80	70	60	50	40	35	25
B (*Max*)	15	12	11	10	9	9	9	8	7	7	6	5
C (*Max*)	230	204	152	120	108	98	88	76	64	54	47	35
D	17-20	16-18	15-17	13-15	13-15	12-14	12-14	11-13	10-12	10-12	8-10	5-8
E	1·5	1·5	1·5	1·25	1·25	1·25	1·00	0·75	0·75	0·75	0·75	0·75
F	50-75	40-65	35-60	33-50	33-50	30-45	30-45	20-30	15-22	15-22	10-15	7-10
H	2·5	2·5	2·5	2·5	2·5	2·5	2·5	2	2	2	2	2

Dimensions for Circular Bubbles

Dimension				
d	24	18	15	12
h	9	9	6	6

NOTE — The pip should be as small as possible.

3.3 Sensitivities

The sensitivities for cylindrical and circular bubbles shall be as given in Table 2.

4 MATERIALS

4.1 Bubbles

4.1.1 *Glass Tube*

The glass tube used shall be well annealed, transparent, free from striae, flaws and other defect and of 1·25 to 2·5 mm wall thickness. The composition of the glass shall be such that it is not reacted upon by the filling liquid or colouring material used. Borosilicate or soft soda glass tubes are suitable.

4.1.2 *Filling Liquid*

Ethyl ether, industrial methylated spirit (Grade I), methyl alcohol, acetone, absolute alcohol or any other suitable liquid shall be used. The liquid shall be clear, shall not be discoloured and shall not cloud or noticeably change in fluidity with age or at temperature as low as —40°C. The liquid shall be chemically inert to the glass tube and the colouring material used. The liquid shall be free of water and impurities and shall not decompose under light and temperature.

4.1.3 *Colouring Material*

The filling liquid shall not normally be coloured. If specified by the purchaser, fluorescent colouring materials, such as eosine for orange colour or fluorescein for intense colour, may by used.

4.2 Mounts

4.2.1 *Metals*

Metal rods and plates used in the manufacture of mounts for bubbles shall be of the best quality and free from defects. Non-magnetic materials shall be used, if specifically desired by the purchaser.

4.2.2 *Plaster of Paris*

Perfectly white surgical plaster of Paris shall be used for mounting the bubbles.

4.2.3 *Plastic Guard*

PVC or acrylic plastic sheet or similar suitable material optically worked shall be used in the manufacture of the plastic guard. It shall be colourless, transparent and dimensionally stable under tropical conditions.

5. CONSTRUCTION AND WORKMANSHIP

5.1 General

5.1.1 The filling liquid inside the bubble shall be so adjusted before sealing that, due to partial filling, a bubble of mixed air and liquid vapour is formed inside.

5.1.2 The dimension of the glass tube shall be so proportioned and the filling liquid inside the glass tube shall be so adjusted that both ends of the bubble may always be read against the scale over a temperature range of 5 to 45°C and the air-bell shall retain an effective length for accurate measurements up to 70°C

NOTE — To achieve this, it is recommended that alteration in length of a bubble for a temperature change of one degree centigrade anywhere between 5 to 45°C should not exceed one percent.

5.1.3 In case of mounted bubbles, the glass tubes shall be housed in the case with the help of plaster of Paris, which shall form a perfectly white background. The mounting shall be provided with an opening for observing movement of air-bell in various graduated positions. Mounted bubbles may also be provided with a protective covering of stout strip of transparent plastic.

5.1.4 The filling pip of the bubbles while cased in the mount with the plaster of Paris shall not be covered by the plaster, and any plaster adhering to the pip shall be removed.

5.2 Cylindrical Bubbles

5.2.1 The vial of cylindrical bubbles shall be processed internally so that, in a longitudinal section formed by a vertical plane through the axis of the vial, the surface in contact with the air-bell is a circular arc.

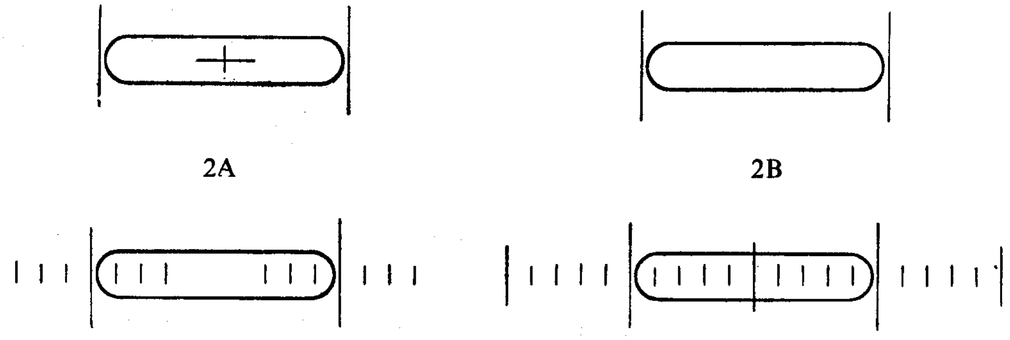
5.2.2 The ends of the glass bodies shall be approximately hemispherical and shall be drawn to thinner sections to facilitate quick sealing after filling. The tips shall be rounded off smoothly leaving no sharp projections.

5.2.3 *Graduation*

The top of the bubble shall be graduated preferably by etching to assist in bringing the air-bell in the centre of its run, and to indicate the movement of the air-bell for a specified tilt indicated by such spacings where provided (*see* Fig. 2 and Fig. 3).

5.2.3.1 On cylindrical bubbles two long lines shall be marked such that the spacing between them would indicate the length of the bubbles at a temperature of 27°C. These lines shall also indicate the position for the air-bell at the centre of its run, showing that the bubble is in a horizontal plane. Scale marking (*see* Fig. 2C and Fig. 2D) shall be made on all cylindrical bubbles at 2·5 mm space, commencing from long centring lines and on either side of them, the outer lines being filled in black and the inner lines in red. The thickness of the lines shall be 0·25 ± 0·05 mm. The blank space at the centre shall be one-third of the air-bell length at a temperature of 27°C.

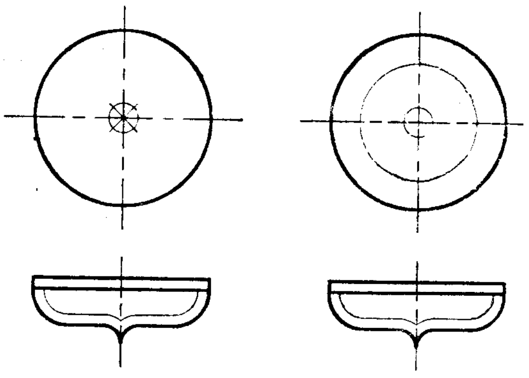
5.2.3.2 The two major graduation marks of any scale shall be clearly designated by their increased length and/or their being terminated by dots. They shall be of the same length and shall indicate the



2A 2B

2C 2D

FIG. 2 FORMS OF VIAL GRADUATION MARKS



3A 3B

FIG. 3 CIRCULAR BUBBLE WITH GRADUATION

position of the bubble at the centre of its run.

These major graduation marks shall be separated by a distance equal to the length of the bubble plus 0·5 mm to 3 mm at 27°C.

5.2.3.3 All graduation marks shall be straight with sharp edges, at right angles to the longitudinal axis of the vial and of a uniform thickness equal to 0·25 mm ± 20 percent. An imaginary centre line drawn through them shall be parallel to the same longitudinal axis.

5.2.3.4 When the scale is of the continuous type, every fifth line shall be extended for ease of reading (*see* Fig. 2D). All intermediate lines shall be of the same length.

5.2.3.5 As viewed in plan, the length of the shorter lines shall approximate to one third the diameter of the vial and the longer graduation marks to one half the vial diameter. All graduation marks shall be permanent and should normally be black.

Other colours of graduation mark shall be subject to agreement between the user and the manufacturer.

5.2.4 In certain bubbles which have no graduations (*see* Fig. 2B), an optical arrangement shall be provided to enable the air-bell to be viewed so that its two ends appear adjacent to each other. When the bubble is central, the two ends shall appear to rest side by side in the same line.

5.2.4.1 Bubbles may be supplied without markings in which case the centre of the effective range and roll shall be marked, preferably by etching, with a plus sign (+) to facilitate mountings (*see* Fig. 2A).

5.3 Circular Bubbles

5.3.1 In the case of circular bubbles, the glass component may be made of one or two parts. Precision circular bubbles are normally made of two parts cemented or fused together. The top part is invariably worked to a specified radius, the bottom part of the bubble is drawn to a thinner section to facilitate quick sealing after filling.

5.3.2 The inside of the circular bubbles shall be ground to a regular spherical curvature.

5.3.3 *Graduation*

On circular bubbles, there shall be one small circle representing the diameter of the air-bell at 27°C crossed by two lines mutually perpendicular to each other (*see* Fig. 3A), or an additional outer concentric circle (*see* Fig. 2B). The circular graduation mark may be etched, printed or formed on either the outer or inner side of the vial. The graduation mark when inside must not interfere the movement of the air-bell. The interval between the two circles in the later type (*see* Fig. 2B) shall be 4 mm. The thickness of the lines shall be 0·25 mm ± 0·05 mm.

6 TESTS AND REQUIREMENTS

6.1 Sensitivity

The sensitivity of a bubble may be tested by the method described in Annex A on a suitable testing instrument (*see* Fig. 4). The sensitivity of a bubble shall not differ from the sensitivity value marked on the bubble by more than the amount specified in Table 2.

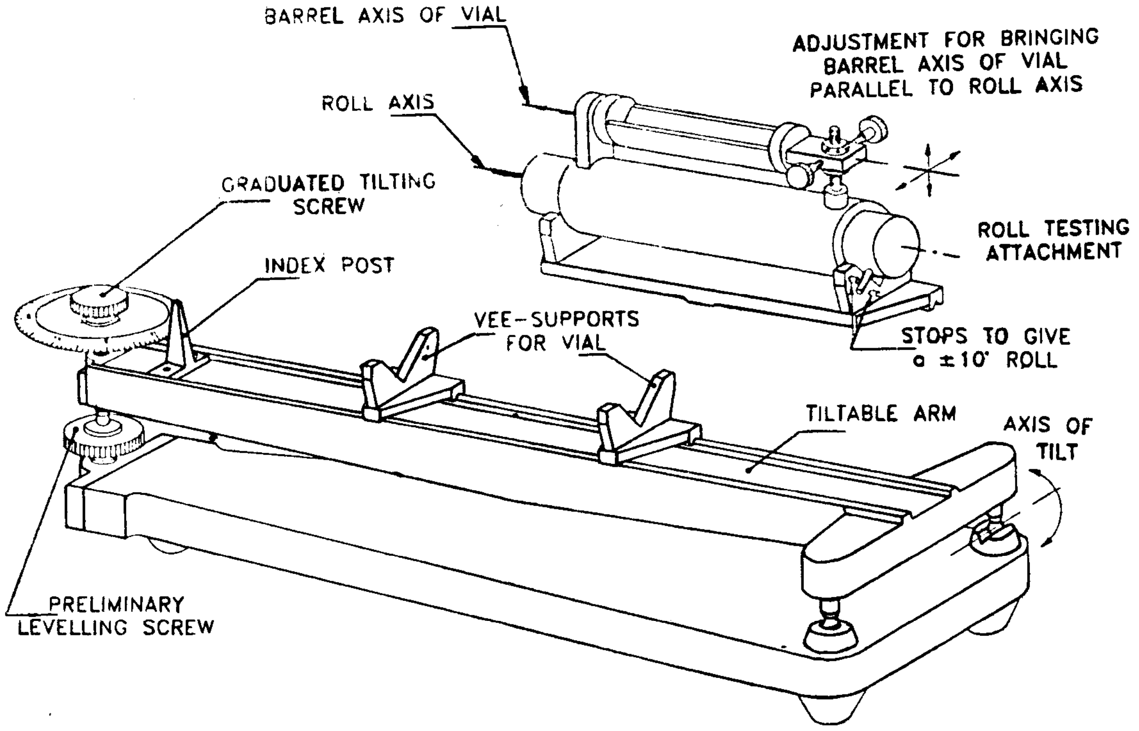


FIG. 4 DIAGRAM ILLUSTRATING BASIC PRINCIPLES OF VIAL TESTING EQUIPMENT

Table 2 Sensitivity Range and Permissible Errors for Sensitivity, Consistency and Roll
(*Clauses* 3.3, 6.1 *and* 6.3)

Type	Sensitivity Range for 2·5 mm Run of the Air-Bell	Tolerance on		
		Sensitivity	Consistency	Roll
(1)	(2)	(3)	(4)	(5)
Cylindrical	10 sec	± 2 sec	1 sec	2 sec
	15 sec	± 2 sec	1 sec	2 sec
	20 sec	± 3 sec	2 sec	2 sec
	30 sec	± 5 sec	3 sec	3 sec
	45 sec	± 10 sec	5 sec	5 see
	1 min	± 10 sec	5 sec	5 sec
	1 min 30 sec	± 20 sec	10 sec	10 sec
	2 min 30 sec	± 30 sec	15 sec	15 sec
	5 min	± 1 min	30 sec	30 sec
	10 min	± 2 min	30 sec	30 sec
	20 min	± 4 min	1 min	1 min
	40 min	± 6 min	2 min	2 min
Circular	10 min	± 3 min	30 sec	—
	25 min	± 5 min	1 min	—

6.2 Consistency

The consistency of a bubble may be tested by the method described in Annex A. There shall be no departure from the mean of six identical settings of bubble tilt greater than that given in Table 2. This test shall be carried out throughout the effective range.

6.3 Roll Error

When a ±10° angle of roll is introduced, the minimum amount of longitudinal movement is the roll error. The roll error may be tested by the method described in Annex A. The air-bell shall remain in the centre of its run within the limits specified in Table 2.

6.4 Sluggishness

After being tilted through an angle of three minutes from its position of rest, the air-bell shall come to rest in three seconds after the tilting is stopped.

6.5 Total Error

The total error in the bubble resulting from lack of consistency, and roll and errors of graduation shall not exceed 10 percent of the marked sensitivity value.

6.6 Heat

The bubble shall be placed in an electric oven and the temperature shall be raised gradually at the rate of 1°C per minute (averaged 5°C over a period of not more than five minutes) to a temperature of 65°C and shall be retained at this temperature for three hours. The air-bell shall not entirely disappear and retain the effective length for accurate measurement up to this temperature. This test is applicable to both mounted and unmounted bubbles.

NOTE—This test should be carried out in such a way the bubbles do not come in contact with a hot metallic surface resulting in cracks due to localized heating.

6.7 The bubble shall be placed in a cold chamber and the temperature shall be lowered gradually at the rate of 1°C per minute (averaged 5°C over a period of not more than five minutes) till it attains a temperature of −30°C and kept at this temperature for three hours. The air-bell shall retain the effective length and there shall be no damage to the bubbles.

6.8 Mounted Bubbles

In the case of mounted bubbles (cylindrical or circular) provided with a flat base, care shall be taken to see that the air-bell is in the centre (zero position) when the case is laid on a horizontal plane before any other tests are carried out.

7 MARKING

7.1 The bubble shall be suitably and legibly marked preferably near the centre with their measured values of sensitivity, so that these can be identified even when mounted in a case.

7.2 Each bubbles shall be legibly and permanently engraved with the manufacturer's name or trade-mark.

7.3 Standard Marking

Details available with the Bureau of Indian Standards.

8 PACKING AND PACKAGING

8.1 The bubbles shall be wrapped in tissue paper and over-wrapped with soft packing material. The required quantity shall be suitably packed in a wooden box lined with brown paper using fine saw dust as packing and cushioning material. Care shall be taken that the packing box is completely full so that the bubbles inside shall have no chance to move about during transit.

ANNEX A

(*Clauses* 6.1, 6.2 *and* 6.3)

RECOMMENDED METHOD OF TESTING

A-1 INTRODUCTION

This is a method of testing regarded as suitable in the majority of cases. Where tests other than these are used they should be agreed between the user and the manufacturer.

A-2 CYLINDRICAL BUBBLES

A-2.1 Testing Equipment

A form of testing equipment (*see* Fig. 4) should comprise a robust table or arm capable of being tilted about a horizontal axis and carrying vees so disposed that the length of any vial bubble laid in them will be at right angles to this axis. The table or arm should be equipped with a measuring screw or other such means capable of indicating the tilt of the table to the appropriate accuracy.

In addition, to test for roll error, provision should be made for lateral adjustment of the vees and independent rotation of that section of the table on which they are carried through an angle of ±10° about an axis lying along the length of the tilting table.

A-3 TEST PRELIMINARIES

A-3.1 The bubble should be allowed to assume room temperature. When rested on the vees the bubble should, prior to the commencement of any test, be oscillated by means of the measuring screw so that the bubble runs from end to end in order to overcome static resistance and dissipate any heat gained through handling.

A-3.2 The table should then be adjusted to bring the bubble to the limit of its range and then tilted slowly to check that the bubble traverses the range with a consistently smooth motion, that is free from so-called 'stickness'.

A-4 SENSITIVITY TEST

A-4.1 The bubble should be tested by bringing one end of the air-bell immediately under one of the end graduation marks, its approach being from beyond the graduation marks themselves in order to eliminate the possibility of backlash in the tilting mechanism. The measuring screw reading is then recorded. The table should then be further advanced until the same end of the bubble is brought in to coincide with the next graduation and the inclination again recorded. This procedure should be repeated for all permissible graduation marks and the successive differences obtained. A similar series of readings should then be obtained using the other bubble end and the corresponding graduation marks at that end of the scale the motion of the tilting screw this time being in the opposite direction. If the vial is graduated as shown in Fig. 2 A, B or C a hypothetical scale spacing of 2·5 mm should be assumed unless otherwise specified, the graduation marks being provided by a suitable graduated transparent scale supported above the bubble. The bubble should be tested through two such graduation intervals at each end of the bubble.

A-5 CONSISTENCY TEST

A-5.1 The bubble should be tested by coinciding one end of the air-bell with a particular setting mark and recording the table tilt; this tilt should be sensibly disturbed and the initial position of the bubble restored. Five such resettings (giving six readings), with the air-bell approaching its position from alternatively opposite directions should be made and the tilt of the table recorded for each. The above procedure may be repeated for several setting mark positions.

A-6 ROLL ERROR TEST

A-6.1 The air-bell is first brought to the centre of its run; the supporting vees are then adjusted by trial and error until the movement of the bubble is brought to an irreducible minimum when a ± 10° roll is applied. This movement constitutes the roll error.

NOTES

1 This test is to determine the departure from a true circular cross section of the barrel-ground inner surface of the vial and is not intended to ascertain the parallelism existing between the axis of the internally ground surface and the axis of the outer cylinder form.

2 The ±10° roll has been selected in order that the roll error will be a measurable quantity. In normal circumstances the angle of roll is much smaller than 10° and any resulting error is insignificant in relation to the consistency.

A-7 TESTING OF CIRCULAR BUBBLES

A-7.1 The equipment and tests should be the same as those used for testing cylindrical vials, a special attachment being provided on the tilting table to hold the circular vials. A graduated scale should be placed over the vials to enable the appropriate readings to be made. Temporary markings may, however, be used to serve the same purpose.

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